PATENT SPECIFICATION

781,356

Date of Application and filing Complete Specification: Sept. 28, 1955. No. 27616/55.

Application made in United States of America on Oct. 1, 1954.

Complete Specification Published: Aug. 21, 1957.

Index at acceptance:—Class 4, A6(A1B:A3B:A5:B2A:B2D).

International Classification:—B64c.

COMPLETE SPECIFICATION

Improvements in or relating to Helicopters

We, UNITED AIRCRAFT CORPORATION, a Corporation organized under the Laws of the State of Delaware, United States of America, of 400 Main Street, East Hartford 8, Connecticut, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to rotary wing aircraft.

When rotary wing aircraft such as helicopters are used on surface ships, for example, aircraft carriers, it is necessary to fold the blades so that the helicopter can be carried below deck on elevators of standard size. This folding and unfolding of the rotor blades must usually be done while the ship is under way, frequently at full speed, and must be accomplished quickly.

One object of this invention is to provide mechanism which is automatically operative under the control of the pilot for folding and unfolding the main sustaining rotor blades of a rotary wing aircraft.

Another object of this invention is to provide improved mechanism for controlling the blade locks and their associated pitch controls in the proper sequence relative to the blade folding and unfolding operations.

These and other objects and advantages of the invention will be evident or will be pointed out in connection with the following detailed description of one embodiment of the invention shown by way of example in the accompanying drawings, in which:

Fig. 1 is a side elevation of a helicopter embodying the invention;

Fig. 2 is a side elevation of the main sustaining rotor of the helicopter of Fig. 1 with the blades broken away and parts omitted for purposes of illustration;

Fig. 3 is a simplified very diagrammatic plan view of the rotor of Fig. 2 illustrating the way a five-bladed rotor is folded in accordance with this invention, the blades being shown in the position they occupy just prior to completion of the folding cycle;

Fig. 3A is a detail elevation taken on line 3A—3A of Fig. 3, showing the inclination of the folding hinge of the No. 4 blade;

Fig. 4 is a plan view of the rotor with the hydraulic lines removed, the blades being broken away for purposes of illustration;

Fig. 5 is an enlarged detail view of the rotor in the vicinity of the attaching means for one of the blades, showing the pivot about which the blade folds and the blade pitch control means at the blade root;

Fig. 5A is a detail view on line 5A—5A of Fig. 5;

Fig. 6 is a diagrammatic view illustrating the hydraulic system;

Fig. 7 is a phantom view similar to Fig. 5 showing the conduits connected to the actuating hydraulic struts; and

Fig. 8 is a diagrammatic view illustrating the primary components of the electrical and associated hydraulic circuits.

Referring to these drawings in detail, Fig. 1 shows a helicopter having a fuselage 10 including a cargo or passenger compartment 12 which extends from the nose of the ship well aft into the tail cone 14 and a forward pilot's compartment 16 above the cargo compartment. A tail rotor pylon 18 is also provided having the usual anti-torque tail rotor 20 mounted thereon for rotation about a

[Price 3/6]

generally horizontal axis. A main sustaining rotor 22 is mounted on an upright tubular shaft 24 which extends from the main rotor pylon 26 located just aft of the pilot's compartment. As shown herein the main rotor has five blades 27 although the number of blades used may vary in different aircraft.

Two engines are provided to drive the main and tail rotors, each mounted in a separate nacelle 28, one of which is shown in Fig. 1. These nacelles are carried by stub wings 30 projecting laterally from opposite sides of the fuselage, one of which is shown in dotted lines in Fig. 1. The usual main and auxiliary landing gears 32 and 34 are provided for supporting the ship on the ground and may be retracted in flight in a well-known manner.

This invention is principally concerned with a means for automatically folding and unfolding the main sustaining rotor blades 27. The folding mechanism provided for each blade is the same. Although one blade, the indexing blade, does not fold, it is provided with the same folding mechanism for purposes of balance, these parts being utilized as carried spares. The blades rotate in counterclockwise direction as viewed from above and for purposes of description the blades are numbered counterclockwise from 1 to 5, the No. 1 blade being the indexing blade which is positioned over the tail cone during folding and unfolding of the blades.

The main sustaining rotor 22 consists of spaced upper and lower plates 36 and 38 (Fig. 2) carried by shaft 24 and between which the blades 27 are pivotally mounted for flapping movement about generally horizontal flapping hinges 40 (Fig. 5) and for movement in the plane of blade rotation about generally vertical drag hinges 42. Considering one of the five blades, it will be noted that in this rotor the axes of the drag hinge and the flapping hinge of the blade intersect each other. A flapping link 44 (Fig. 2) which carries the blade is pivoted on the flapping hinge. The flapping link has a spindle 95 (Fig. 3A and 5) which extends axially of the blade and on which the root sleeve of the blade is journalled for pitch changing movement. A collar 46 at the inboard end of the blade carries the usual blade horn, hereinafter referred to, for changing the pitch of the blade. The flapping link 44 and the collar 46 are provided with laterally projecting adjacent lugs 48 and 50, respectively, having aligned passages in which a locking pin 52 carried by lug 50 can be reciprocated to lock the blade sleeve against angular movement relative to the flapping link. A hydraulic strut including cylinder 54 carried by lug 50 controls the reciprocation of the pin 52 into and out of locking position.

Horn 56 on collar 46 (Fig. 2) is connected for universal movement at 57 to the lower end of a rod 58, the upper end of which is connected by clevis 59 to the rotatable lug extremity of an arm 60 (Fig. 4) fixed to a rocker shaft 62. Shaft 62 is journalled on one of the five blade supporting arms 64 of the spider 36 and has a second arm 68 pivotally connected at 70 to the upper end of a push-pull rod 72 (Fig. 2). The lower end of rod 72 is connected for universal movement at 74 to one lug of the rotatable portion 76 of a usual swash plate, the non-rotating portion 78 of which is prevented from rotation by a usual scissors 80. The non-rotating swash plate portion 78 has four points 84, two of which are shown in Fig. 2. The right hand point 84 as viewed in this figure is attached to the scissors 80. The other three points 84 are connected to hydraulic servos, not shown. One of these servo connection points is shown in Fig. 2. Thus to fly forward the right front point 84 is lowered and to fly backward it is raised. To fly to the left the right rear point 84 is raised and to fly to the right it is lowered. When all three servos are actuated together, the swash plate is moved bodily up or down on the shaft 24 to change the pitch of all the blades collectively. The servos as usual are controlled by the pilot by mechanism, not shown.

Referring to Fig. 5, it will be noted that each blade has a fitting 88 which terminates in an inboard annular flange 90. Flange 90 is bolted to a similar flange 92 of a blade attaching member 94 forming one part of a two-part blade folding hinge mechanism, the other part 96 of which is in the form of a sleeve, previously mentioned, journalled on the blade feathering spindle 95 (Fig. 3A) and has an annular flange 98 which is bolted to collar 46. Hinge parts 94 and 96 are pivotally connected by a hinge pin 100 which is the pin about the axis of which the blade folds and unfolds. This hinge is best shown in Figs. 5 and 5A. Hinge part 94 has two locking lugs 102 which enter into recesses 104 in sleeve 96, the lugs 102 and the overlying portions of sleeve 96 defining the recess having aligned apertures 106 in which blade locking pins 108 are reciprocable and in co-operation with hinge pin 100 lock the blade in its flight, or unfolded, position. Two such pins 108 are provided (Fig. 6).

The pins 108 are attached to a yoke 110 which in turn is attached to the piston rod of piston 112 hydraulically reciprocable in cylinder 114 of strut 115 which is carried by sleeve 96, the piston and cylinder co-operating to withdraw and insert the pins to unlock and lock the blade folding hinge.

The flapping hinge 40 for each blade has an axial extension on which a damper attaching horizontal sleeve 116 is journalled. The damper consists of a cylinder 118 (Fig. 4) pivotally mounted at 120 on the radial spider arm 64 of its associated blade and a piston 121 having a piston rod 122 (Fig. 6) pivotally connected at 124 to the horizontal sleeve 116, thus forming in effect a universal joint connection of the damper piston rod with the flapping hinge 40. As shown most clearly in Fig. 6, the damper cylinder 118 has an extension cylinder 126 in which a piston 128 is reciprocable. Piston 128 is carried by the end 130 of piston rod 122 and under the action of hydraulic fluid entering the cylinder at the left of the piston moves the piston rod 122 and hence swings the blade about its drag hinge until a stop 132 engages the end of cylinder 126, in which position of the damper parts, the blade is in its normal position for folding in which it is extended forward of the radial axis to full autorotative position.

The hinge part 94 has an arm 134 securely bolted thereto and provided with an enlarged somewhat semi-circular end portion 135 which underlies a sector gear 136 and is secured thereto by a plurality of bolts 137 arranged in a circular arc so that the angular relation of the gear 136 relative to the portion 135 may be changed. The sector gear 136 is operated by a rack 140 which forms an extension of piston rod 142 of a hydraulic strut 145 including cylinder 144 rigidly supported by bracket 147 (Fig. 5).

Hinge pin 100 additionally carries immediately beneath arm 134 an arm 135*a* which is fixed to sleeve 96 by a bolt (not shown). That portion of pin 100 where it passes through arm 135*a* is of square cross-section, as is its mating hole in 135*a*, with the result that there is a rigid connection between pin 100 and fixed arm 135*a*. An arm 134*a*, which overlies the sector gear 136, carries at its free end bolt 135*b* and a roller which engages the smooth back of rack 140 and holds the rack firmly in position to mesh with sector gear 136. Bolt 135*b* also extends through the free end of arm 135*a* which is fixed to sleeve 96. Hence arms 134*a* and 135*a* and pin 100 are secured rigidly to hinge part 96, while arm 134 and gear 136 may move about pin 100 with hinge part 94. It is thus evident that hinge part 94 and the blade may be swung away from sleeve 96 in the desired blade folding motion by rack actuation of sector gear 136.

In the process of folding and unfolding the blades, the operation of the drag hinge dampers for positioning the blades, the operation of the locking pins 52 and the hinge locking pins 108, and the actual folding and unfolding operation of the blades themselves must be performed in the proper sequence. To this end sequence valves are provided in the hydraulic lines. Referring to Fig. 6, a sequence valve 148 of usual construction is provided on each damper cylinder 126 having a valve member constantly spring biased against its seat and having a valve stem which projects slightly into the cylinder 126 into position to be depressed by piston 128 to open the valve whenever the piston moves over the stem. The piston 128 has a bevelled edge on its right hand face as viewed in Fig. 6, which enables it to cam the stem of the valve 148 downwardly as it moves over the stem.

A similar sequence valve 150 is likewise associated with each hydraulic cylinder 54 in position to be engaged and opened by pin 52 at the end of its locking stroke. Similarly a sequence valve 152 is provided which is engaged and opened at the end of the unlocking stroke of pins 108. The above sequence valves are operated during the blade folding operation. A sequence valve 154 is also provided for each blade, which is opened at the end of the blade unfolding stroke of the rack 140, as hinge part 94 moves against sleeve 96, all as will be more fully described in connection with the operation of the mechanism. Pins 108 also control a sequence valve 138, constantly biased toward closed position, the stem of which is engaged by piston 112 to open the valve at the end of the locking stroke of these pins.

The hydraulic system includes a pump 156 which takes fluid from a sump 158 and supplies one or the other of the distributors 160, 162 as controlled by the four-way valve 170 to fold or unfold the blades, suitable fluid transfer bearings, or rotating joints, 163 and 163*a* being provided in the hydraulic conduits leading to the distributors. As the mechanism for folding and unfolding the No. 2, No. 3, No. 4, and No. 5 blades is identical, except for variations in adjustment of the mechanism, that of the No. 2 blade only has been shown in Figs. 5, 6 and 7 for simplification. It will be understood that the blade folding movement of all the blades starts simultaneously.

Before the blades can be folded, it is

necessary to index the rotor until the No. 1 blade lies over the tail cone 14. As previously stated the No. 1 blade is the indexing blade and does not itself fold although it carries a full complement of folding mechanism to insure rotor balance. Referring to Fig. 8, if it is desired to fold the blades, the pilot closes rotor indexing switch 204 which supplies voltage from a power source 205 through a conductor 205*a* to the movable switch member 206 of a pilot operable blade folding and unfolding switch. At the same time voltage is applied to conductors 205*b* and 205*c* to energize inner slip ring 208 which is carried by and rotates with the main rotor shaft 24. Simultaneously current flows through conductor 207 and a grounded valve opening solenoid 214 of a hydraulic valve 216. Operation of solenoid 214 supplies hydraulic fluid under pressure through conduit 218 through valve 216 and conduit 211 to hydraulic motor 220 which drives the rotor shaft 24 in a counterclockwise direction as indicated by the arrow in Fig. 8. Fluid from motor 220 returns through conduit 221, valve 216 and conduit 240 in a usual manner. The rotor continues to move in this direction until the jumper 222 carried by the rotor engages contact 224 when current flows from source 205 through switch 204, conductors 205*a*, 205*b*, 205*c*, ring 208, jumper 222 to contact 224 and thence through conductor 210 to a grounded valve closing solenoid 212 which closes hydraulic valve 216 and interrupts the flow of hydraulic fluid to motor 220.

It will be noted that, when the jumper 222 engages contact 224, current will also flow from the source 205 through switch 204, conductors 205*b*, 205*c*, ring 208, jumper 222, contact 224 and conductor 228 through a grounded solenoid 230, thus bridging the contacts 231 which are in the blade folding circuit. If now the pilot moves the switch member 206 from the "OFF" position shown in Fig. 8 into position to engage contact 232, current will flow from source 205 through switch 204, conductor 205*a*, contacts 206, 232, conductor 233, closed relay contacts 231 and conductor 235 to the grounded solenoid 234 which operates the four-way valve 170 to fold the blades as will be hereinafter fully described.

When the pilot desires to unfold the blades to bring the same again into flight position, the movable switch member 206 is moved into engagement with contact 238. Current will now flow from source 205 to switch 204, conductor 205*a*, contacts 206, 238, conductor 237 and grounded solenoid 242 associated with the four-way hydraulic valve 170 which directs fluid to unfold the blades. When the blades have been unfolded, the rotor indexing switch 204 is opened and the movable switch member 206 is moved to the off position shown in Fig. 8. The blade folding and unfolding mechanism associated with the rotor head and controlled by the four-way hydraulic valve 170 will now be described.

Referring to Fig. 6, the blade is in its normal flight position (unfolded) as indicated by the position of the piston 128 in the extreme left end of cylinder 126 in which position the damper piston 121 is free to move through its full stroke; the piston 127 is in the right hand end of cylinder 54 in which pin 52 is withdrawn from lug 48 (Fig. 5); piston 112 is in the left end of cylinder 114 of strut 115 in which pins 108 extend through lugs 102 and lock the blade folding hinge; and the piston 146 is in the right hand end of cylinder 145 which is the extended position of rack 140.

It will be recalled that the No. 1 blade does not fold but remains directly over the tail cone in the position shown in Fig. 3 in which it was left when jumper 222 engaged contact 224 (Fig. 8). Blades No. 2 and No. 5 fold back 72° into the positions shown in Fig. 3 in which they lie alongside blade No. 1 and parallel thereto. During this folding movement blades No. 2 and No. 5 also move upward slightly due to a 3° inclination of their hinge pins 100. Also blades No. 3 and No. 4 are folded aft through 131°, to bring them under blades No. 2 and No. 5 and likewise parallel with blade No. 1. As shown in Fig. 3 blades No. 3 and No. 4 have not completed their folding movement and it will be evident that to do so they must move under the folding hinges of blades No. 2 and No. 5. In order to accomplish this the folding hinge pins 100 of blades No. 3 and No. 4 are inclined so that these pins lie 12° from the vertical, in a direction to cause the tips of these blades to move down as they fold.

The inclination of pins 100 of the blades is possible because of the bolted connection of the flange 98 to collar 46. For example, it will be evident that, by rotating sleeve 96 of blade No. 2 clockwise relative to collar 46, as viewed from the right hand side of Fig. 5, the folding hinge pin 100 of blade No. 2 will be inclined forward at the top in Fig. 3 so as to cause the tips of this blade to rise when folded aft (Fig. 3). Of course, in order to maintain the pitch relationship of the blade the same, an equal counterclockwise rotation of flange 90 relative to flange 92 is required. The dip of blades

No. 3 and No. 4 upon folding is similarly provided. Thus, the hinge pin 100 of blade No. 4 is moved aft at the top in Fig. 3 by clockwise rotation of its flange 98 relative to collar 46 while in the case of blade No. 3 the pin 100 would be moved aft at the top by counterclockwise movement of flange 98 relative to its sleeve 46.

The swinging of the No. 2 and No. 5 blades through an angle of 72° and of the No. 3 and No. 4 blades through 131° is accomplished by adjusting the angle of the sector gears 136 relative to the semicircular portions 135 of straps 134 carried rigidly by hinge parts 94, as permitted by bolts 137.

As the No. 3 and No. 4 blades fold back, there is a tendency for the blade root to swing upwardly about the flapping hinge which would allow the blade assembly to drop at its outer portion. This is prevented by the anti-coning lock 77 which engages an abutment 77' on sleeve 96 (Fig. 2).

With the rotor indexed into the proper position for blade folding, movement of switch member 206 (Fig. 8) into contact with terminal 232 supplies current to solenoid 234 as previously described. Actuation of solenoid 234 permits hydraulic fluid to flow from tank 158 through pump 156, conduit 236, valve 170; conduit 165, rotary valve 163, conduit 167 (Fig. 6), distributor 160 and conduit 169 to the left hand end of cylinder 126. Fluid acting on piston 128 moves the latter to the right until the stop 132 engages the right hand end of cylinder 126. In this position of piston 128, the stem of normally closed valve 148 lies directly beneath the piston and the valve is held open by it so that fluid is now free to flow through conduit 171, valve 148 and conduit 172 to the right hand end of cylinder 54. Fluid acting on piston 127 moves pin 52 to the left against the action of spring 174. During this movement of piston 127 the fluid in cylinder 54 flows through conduit 176, open valve 138, conduits 178 and 180, opened valve 154 and conduits 202 and 182 to distributor 162 and thence through conduit 184, rotating joint 163*a*, conduit 200, valve 170 and conduits 186 and 240 to the sump 158.

As pin 52 moves into lug 48 (Fig. 5) to lock collar 46 to the flapping link 44, it engages the stem of normally closed valve 150 to open the latter and allow fluid to flow from conduit 188, through valve 150, conduits 190 and 192 to cylinder 114, moving piston 112 to the right. The fluid in cylinder 114 flows through conduit 194 into conduit 180 and thence to sump 158 as previously described. As the fluid moves piston 112 to the right, it withdraws pins 108 from lugs 102 of the locking hinge part 94 which leaves the blade free to swing about its hinge pin 100. In the final movement of piston 112 yoke 110 engages the stem of normally closed valve 152 and opens it to admit fluid through conduit 196 to cylinder 144 of the blade actuating strut 145. The fluid in cylinder 144 is free to return through the conduit 182 to sump 158 as the fluid entering through conduit 196 moves the piston 146 to the left to effect folding movement of the blade about its hinge pin 100 through the action of the rack 140 and sector gear 136.

It will be noted that as the blade folds and the root portion 88 of the blade swings about pivot pin 100, the hinge part 94, which in the unfolded position of the blade engages valve stem 198 and holds it open, is removed and under the action of its spring this valve closes. Also, it will be noted that when piston 112 moves to the right, valve 138 also closes under the action of its spring 174.

To move the blades into flight position (unfold) the pilot moves switch member 206 (Fig. 8) to engage contact 238 and a circuit is thereby closed to solenoid 242 of selector valve 170. As a result this valve 170 moves into the full line position shown in Fig. 6 so that fluid under pressure from pump 156 will flow through conduit 236, valve 170, conduit 200, rotating joint 163*a*, conduit 184, distributor 162, and conduit 182 to cylinder 144 to move piston 146 to the right and swing the blade back to normal flight position. As the hinge part 94 moves into engagement with the sleeve 96 it engages the stem 198 of valve 154 and opens the latter to admit fluid through conduit 202, valve 154 and conduits 180 and 194 to cylinder 114. The resulting movement of piston 112 to the left in Fig. 6 causes the locking pins 108 to pass through lugs 102 and enter sleeve 96 to again lock the blade against movement about its hinge pin 100. As piston 112 moves to the left it also withdraws the crossbar 110 allowing valve 152 to close. Also as piston 112 reaches the end of its stroke it opens valve 138 which admits fluid from conduit 178 to conduit 176 and cylinder 54. Fluid admitted to cylinder 54 moves piston 127 to the right in Fig. 6 allowing valve 150 to close and unlocking the pitch control ring 46. This returns the parts to their original position at the beginning of the folding and unfolding cycle.

It will be evident that as a result of this invention it is possible to automatically fold and unfold the blades of a multiblade rotor by controls in the pilot's

compartment. It will also be evident that the pitch changing mechanism of the blades is safeguarded during folding and unfolding of the blades and that the mechanism is such that the various operations are carried out in sequence so that failure of any of the mechanism will immediately become known to the pilot.

It will also be evident that means have been provided for compactly folding the blades of a five-bladed rotor into positions in which all the blades extend aft over the tail cone.

What we claim is :—

1. A helicopter comprising a rotor, each of a plurality of the blades of said rotor being provided with hinge means about the axis of which the blade can be folded and means for locking said hinge means movable between a locking position in which the blade is locked in flight position and an unlocked position in which the blade is free to fold, means responsive to the unlocking operation of said locking means for folding said blades, and means responsive to the movement of said blades from folded position into unfolded position for moving said locking means into locking position.

2. A helicopter comprising a rotor, each of a plurality of the blades of said rotor being provided with hinge means about the axis of which the blade can be folded and means for locking said hinge means with the blade in flight position, means for positioning said blades for folding movement, means responsive to the operation of said positioning means for unlocking said locking means, and means responsive to the unlocking operation of said locking means for folding said blades.

3. A helicopter comprising a rotor having variable pitch blades, each of a plurality of the blades of said rotor being provided with hinge means about the axis of which the blade folds and means for locking said hinge means with the blade in flight position, means for controlling the pitch of said blades, means for positioning said blades for folding movement, means responsive to the operation of said positioning means for locking said pitch-controlling means, means responsive to the locking of said pitch-controlling means for unlocking said locking means, and means responsive to the unlocking operation of said locking means for folding said blades.

4. A helicopter according to Claim 2 or 3, in which each blade is pivotally mounted for movement about a drag hinge, said hinge means permitting blade-folding about an upstanding axis, and said positioning means comprises a hydraulic drag hinge damper controlling the movement of each of said blades in the plane of blade rotation and means for admitting hydraulic fluid to said drag hinge dampers to position said blades about their drag hinges for folding movement.

5. A helicopter according to Claim 4. in which said locking means and said blade-folding mechanism are both hydraulically operated, said means for admitting hydraulic fluid to said drag hinge dampers is pilot-operated, and said one or more responsive means include sequence valve means, whereby operation of said pilot-operated means to supply hydraulic fluid to said drag hinge dampers results in the automatic positioning of the blades for folding, unlocking of said locking means, and folding of said blades or the reverse.

6. A helicopter according to Claim 5. in which said sequence valve means comprises a first sequence valve for supplying hydraulic fluid to said pitch-controlling means to lock the same in response to positioning of said blades, a second sequence valve for supplying hydraulic fluid to said locking means operable upon locking of said pitch-controlling means to unlock said locking means, and a third sequence valve operable upon unlocking of said locking means for supplying hydraulic fluid to said blade-folding mechanism.

7. A helicopter according to Claim 5 or 6, in which said blade-folding mechanism includes a hydraulic strut on each blade, a pinion carried by the root of said blade, and a rack carried by said strut and meshing with said pinion.

8. A helicopter according to any of Claims 1 to 7, which includes means for indexing said rotor to bring a selected blade into aft-extended position, said means responsive to the unlocking of said locking means folding all of the blades except said selected blade.

9. A helicopter according to Claim 8 in which said rotor has five blades equally spaced apart about the rotor axis, and said indexing means brings one blade into aft-extended position in the longitudinal centerline of the helicopter with a first pair of blades extended aft and a second pair of blades extended forward, and in which said blade-folding means comprises a first means for folding the first pair of blades further aft into generally parallel relation with said one blade, and a second means for folding said second pair of blades aft into generally parallel relation with said one blade and into substantially the vertical planes occupied by said first pair of blades.

10. A helicopter according to Claim 9,

in which said first folding means includes means for inclining said first pair of blades upwardly at their tips during the folding operation, and said second folding means includes means for inclining said second pair of blades downwardly at their tips during the folding operation whereby said second pair of blades, when folded, lie beneath said first pair of blades.

11. A helicopter according to any of Claims 1 to 10, in which said rotor includes a hub and a plurality of blade-supporting spindles on said hub, and in which said locking means includes a sleeve journalled on a spindle and forming one part of a blade-folding hinge, a blade pitch-control ring, means for securing said ring to said sleeve in a plurality of angular positions of adjustment of the latter relative to said spindle, and a blade-attachment member pivotally mounted on said sleeve by an upstanding hinge pin and forming the other part of said blade-folding hinge, and in which each blade has a root fitting, means being provided for securing said fittings to said blade-attachment member in a plurality of angular positions of adjustment relative to said spindle axis.

12. A helicopter according to Claim 11, which includes a flapping link pivotally mounted on said hub by a flapping hinge and provided with said blade supporting spindle.

13. A helicopter according to Claim 12, which includes means for locking said ring rigidly to said flapping link in one position of angular adjustment of said ring.

14. A helicopter according to any of Claims 11 to 13, in which said sleeve has an inboard flange abutting said ring, and said blade-attachment member has an outboard flange abutting a flange on said root fitting.

15. A helicopter substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

STEVENS, LANGNER, PARRY & ROLLINSON,
Chartered Patent Agents,
Agents for the Applicants.

Printed for Her Majesty's Stationery Office by Wickes & Andrews, Ltd., E.C.4. 684/2.—1957.
Published at the Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

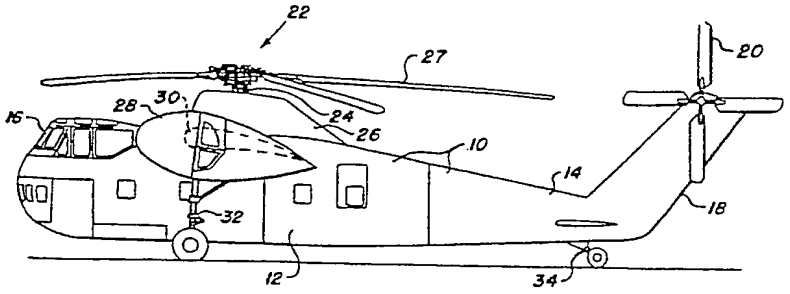


Fig. 1

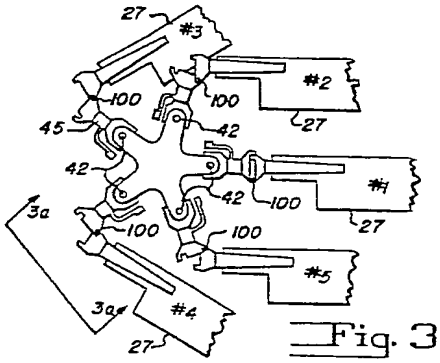


Fig. 3

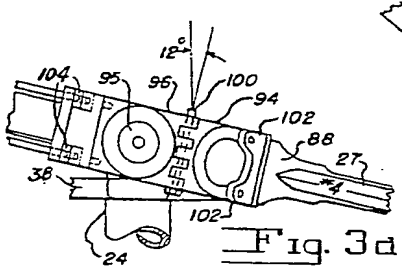


Fig. 3a

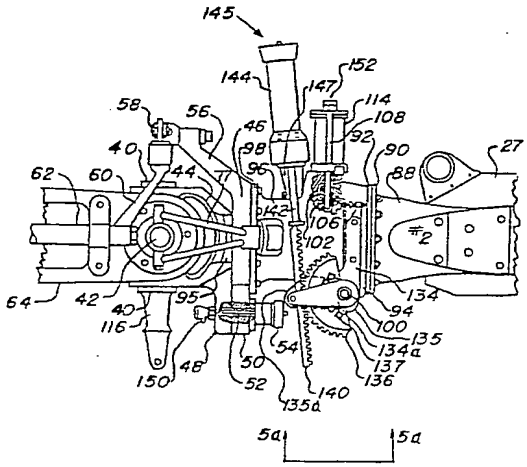


Fig. 5

781356 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

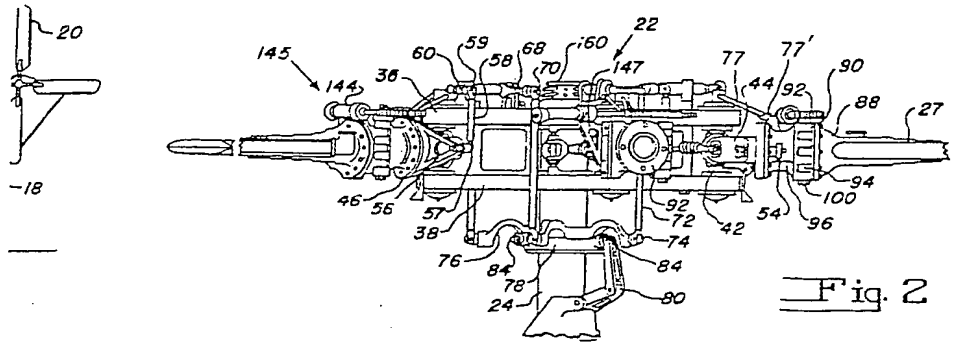


Fig. 2

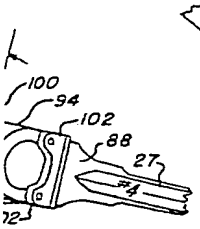


Fig. 3d

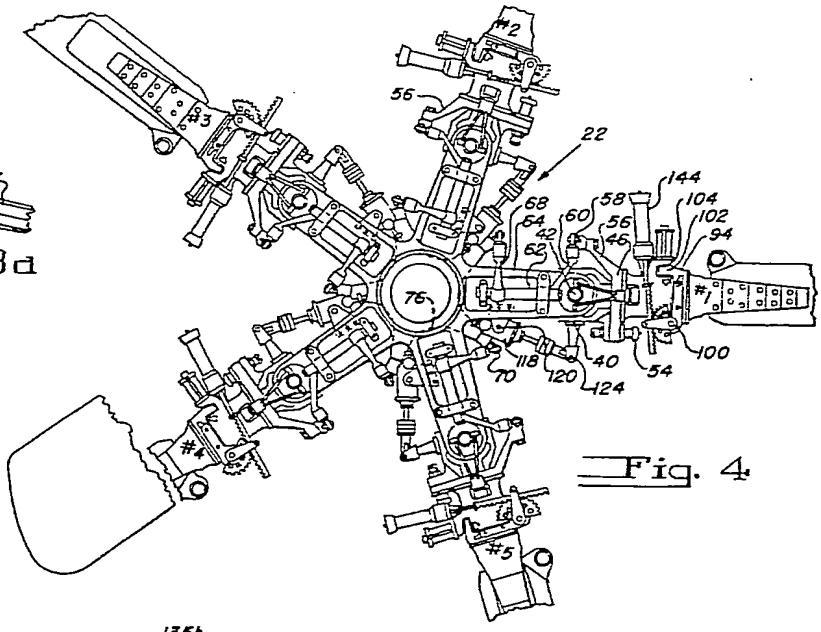
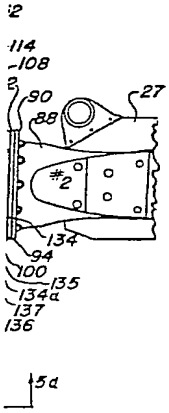


Fig. 4



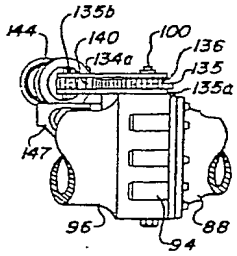


Fig. 5a

781356
2 SHEETS
COMPLETE SPECIFICATION
This drawing is a reproduction of the Original on a reduced scale
Sheet 1

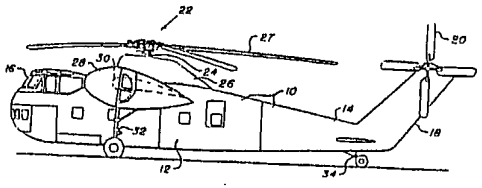


Fig. 1

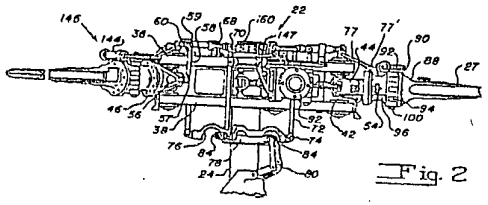


Fig. 2

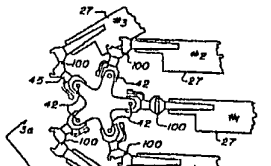


Fig. 3a

Fig. 3

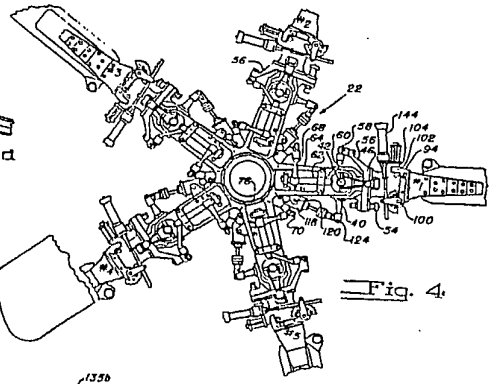


Fig. 4

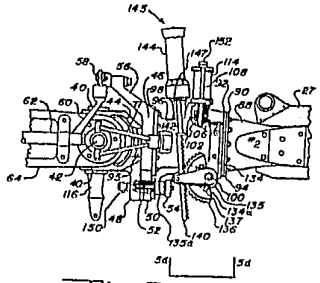


Fig. 5

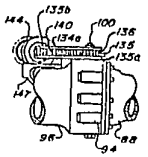


Fig. 5a

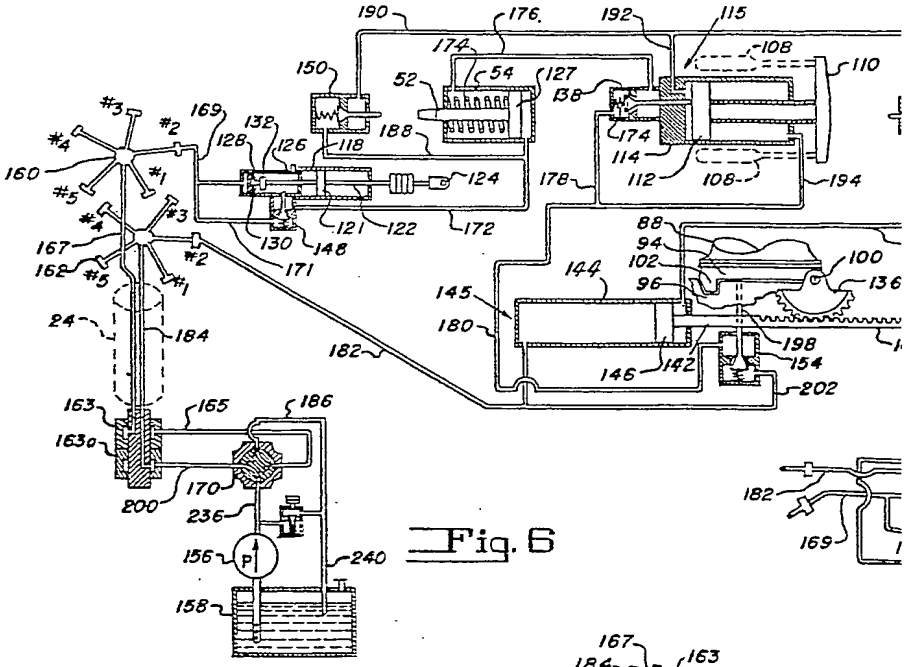
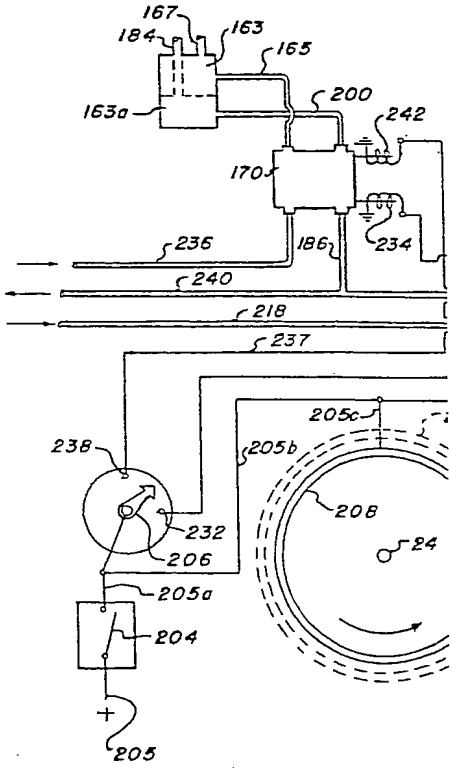


Fig. 6



781356
2 SHEETS

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale

Sheet 2

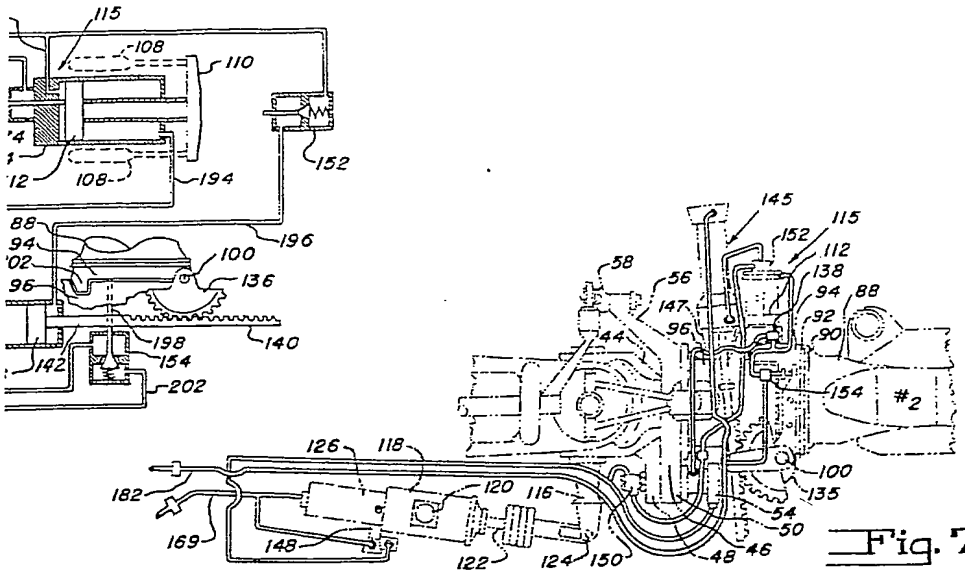


Fig. 7

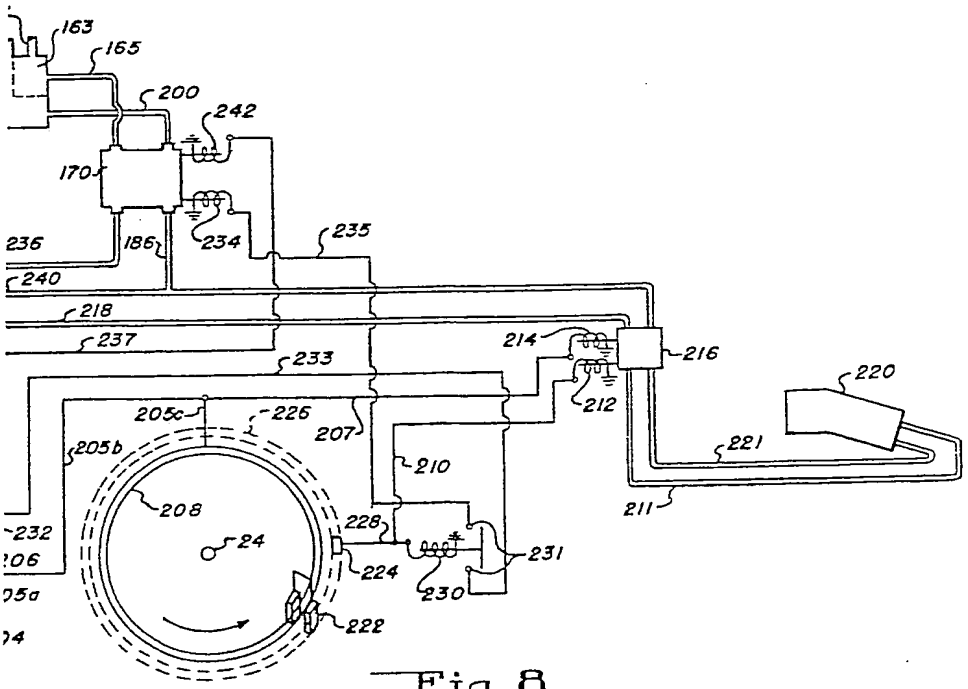


Fig. 8

781356
2 SHEETS
COMPLETE SPECIFICATION
This drawing is a reproduction of the Original on a reduced scale
Sheet 2

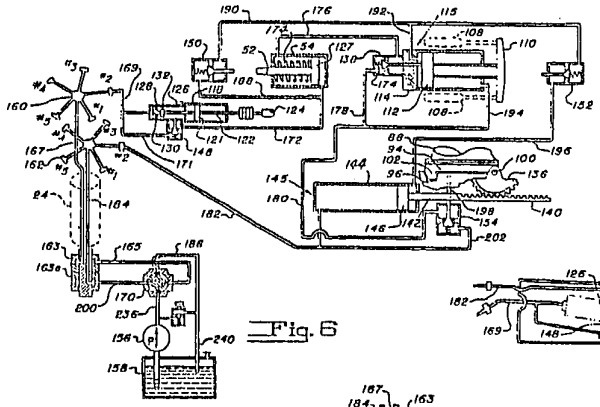


Fig. 6

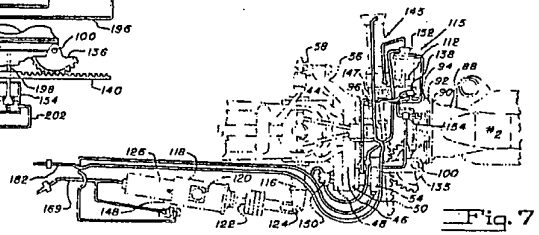


Fig. 7

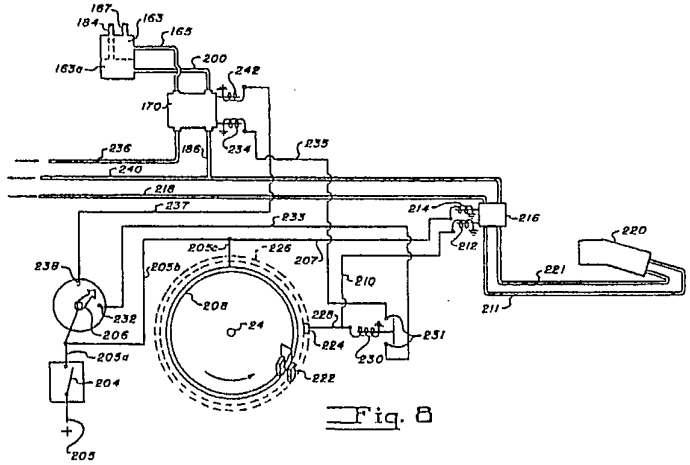


Fig. 8